

Review of Highest-Yield Spine Facts

AAOS Board Preparation and Review Course

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Disclosures

Co-Investigator/Grant Support

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National Institutes of Health

Teaching/Consultant

OrthoFix Spine
AO Spine North America
American Academy of Orthopaedic Surgeons (AAOS)

Equity

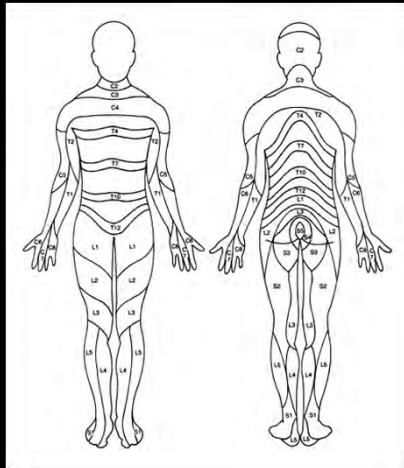
New Era Orthopaedics, LLC
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Royalties

Thieme Medical Publishers
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Physical Examination

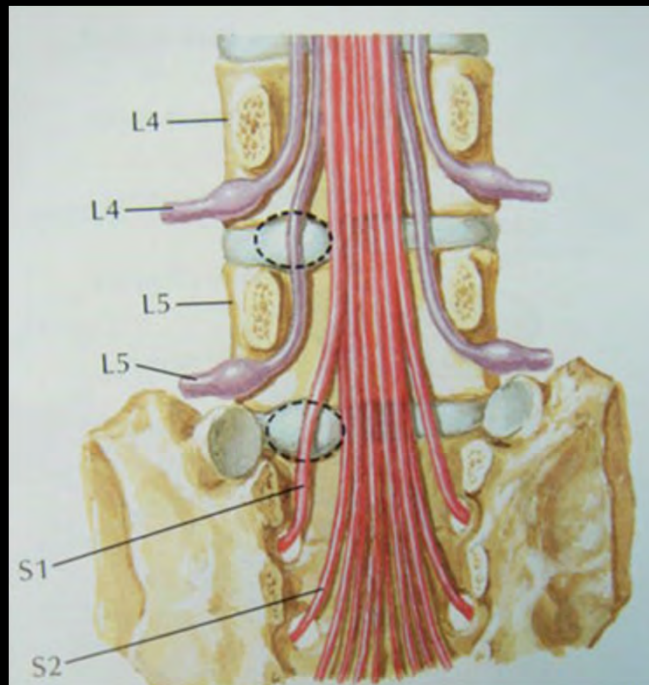
CTQ



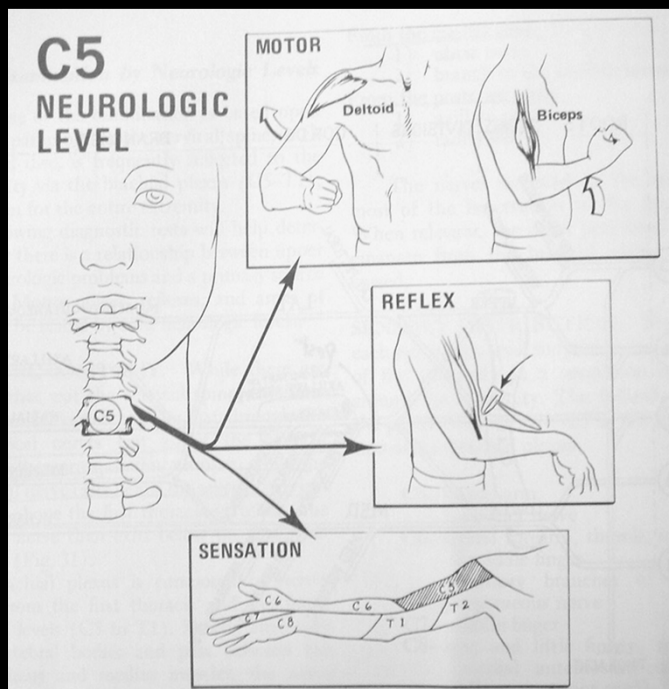
Browner, Jupiter. Skeletal Trauma, 2nd Edition, 1998.

Nerve Roots

- Above corresponding pedicle in cervical spine
- Below corresponding pedicle in lumbar spine



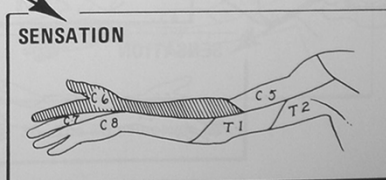
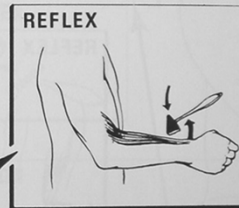
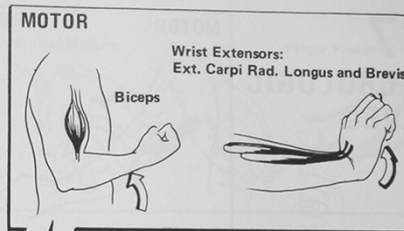
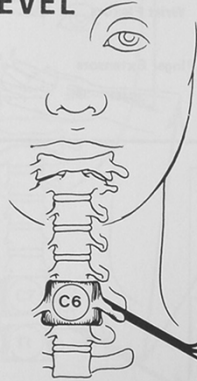
Netter F.



CTQ

Hoppenfeld S. 1976.

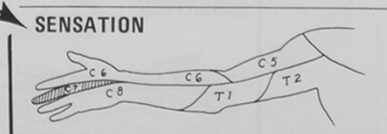
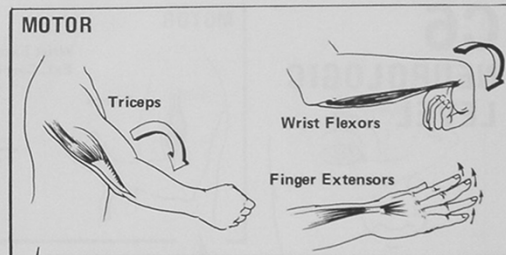
C6 NEUROLOGIC LEVEL



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Hoppenfeld S. 1976.

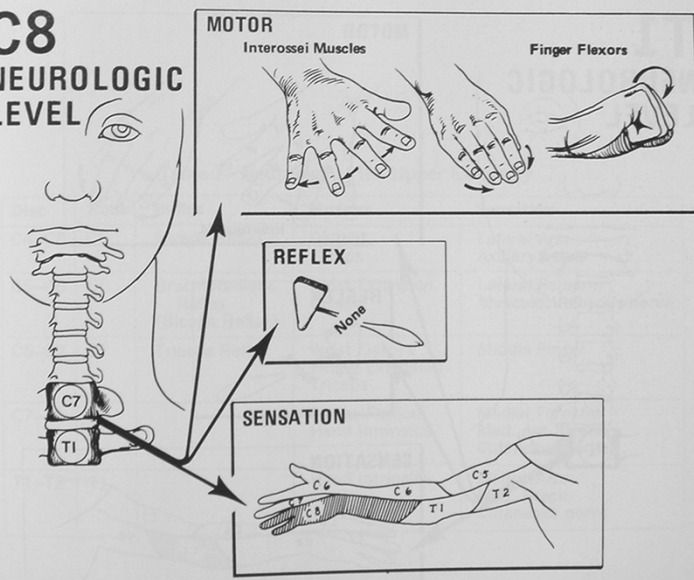
C7 NEUROLOGIC LEVEL



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Hoppenfeld S. 1976.

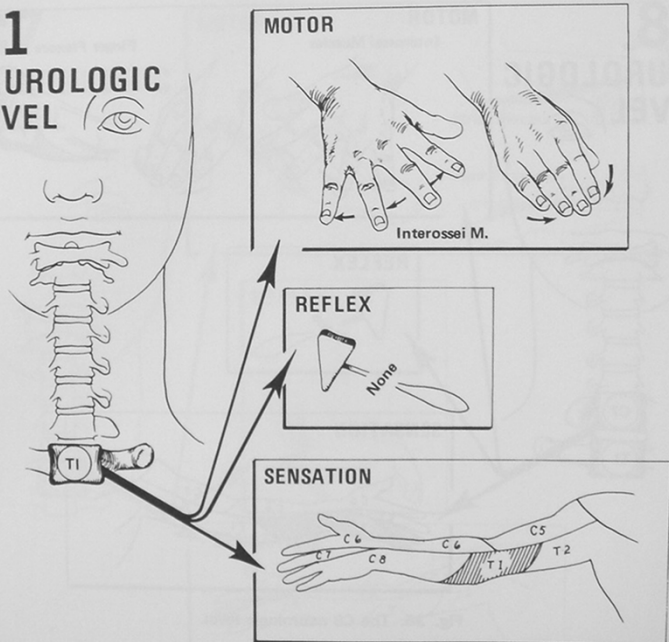
C8 NEUROLOGIC LEVEL



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Hoppenfeld S. 1976.

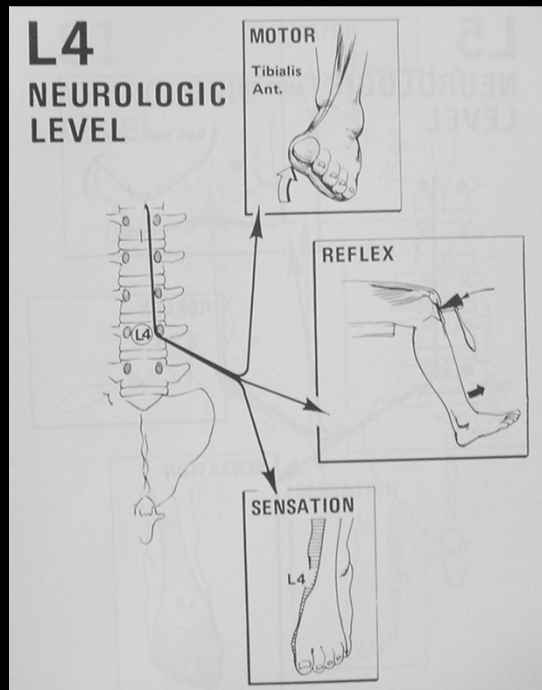
T1 NEUROLOGIC LEVEL



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Hoppenfeld S. 1976.

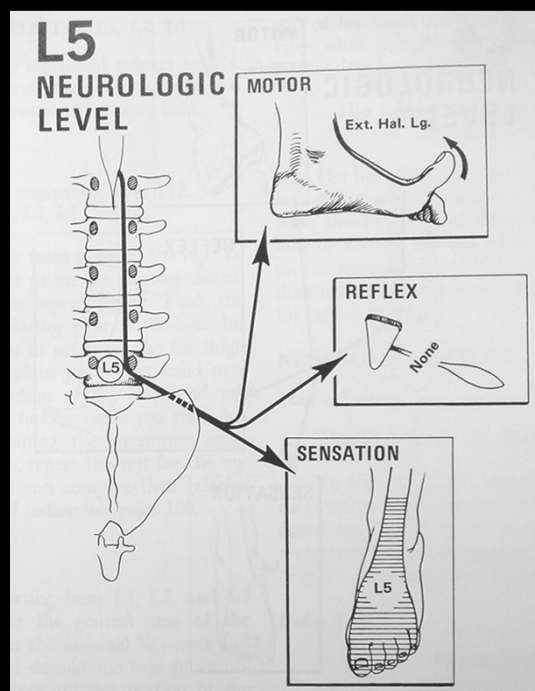
L4 **NEUROLOGIC** **LEVEL**



CTQ

Hoppenfeld S. 1976.

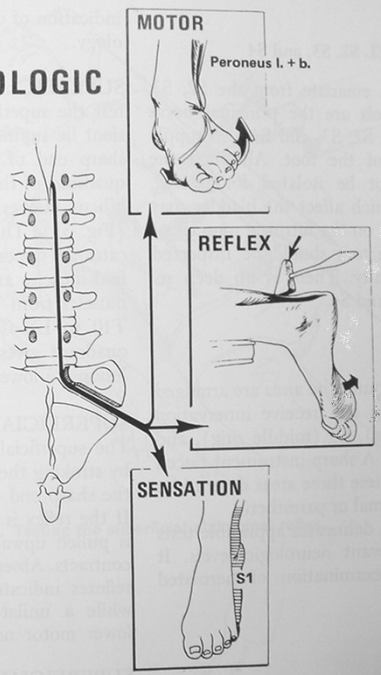
L5 **NEUROLOGIC** **LEVEL**



CTQ

Hoppenfeld S. 1976.

S1 NEUROLOGIC LEVEL



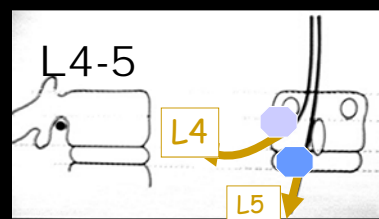
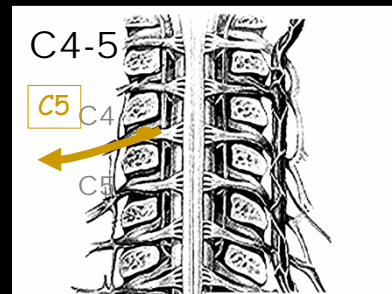
CTQ

Hoppenfeld S, 1976.

High-Yield Fact

- Herniated C4-C5 disc
 - C5 nerve
- Herniated L4-L5 disc
 - Posterolateral
 - L5 nerve root
 - Far lateral
 - L4 nerve root
 - Foraminal stenosis
 - L4 nerve root

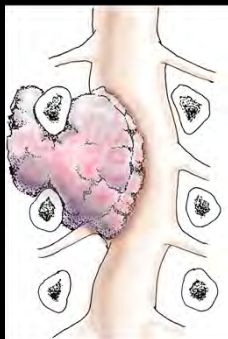
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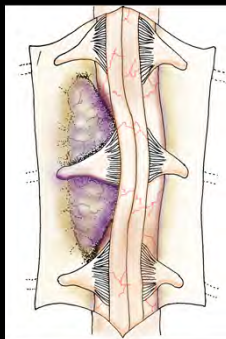
YOU MUST KNOW THIS !!

	MOTOR	SENSORY	REFLEX
C₅	Deltoid/Biceps	Shoulder	Biceps
C₆	Wrist Ext/Biceps	Thumb/Index	Brachioradialis
C₇	Triceps/ Wrist Flexors	Long	Triceps
C₈	Intrinsics/grasp	Ring/Little	Ø
L4	Quad /Hip Add	Lat thigh / Medial Tibia	Patella Tendon
L5	EHL Gluteus medius	Anterolateral leg Dorsum foot	Ø
S1	Gastrocnemius	Lat malleolus/ Lat foot	Achilles

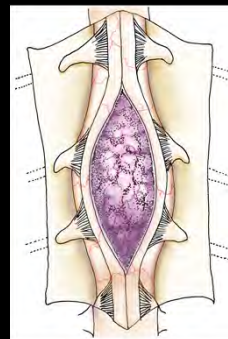
Neoplastic Disease



Extradural



Intradural-Extramedullary



Intramedullary

Neoplastic Disease

I. Extradural

- | | | |
|---------------|---------------------------|-------------------|
| A. Metastases | F. Giant Cell Tumor | K. Chordoma |
| B. Myeloma | G. Osteoid Osteoma | L. Osteosarcoma |
| C. Lymphoma | H. Osteoblastoma | M. Chondrosarcoma |
| D. Hemangioma | I. Eosinophilic Granuloma | N. Osteochondrom |
| E. ABC | J. Ewing's Sarcoma | |

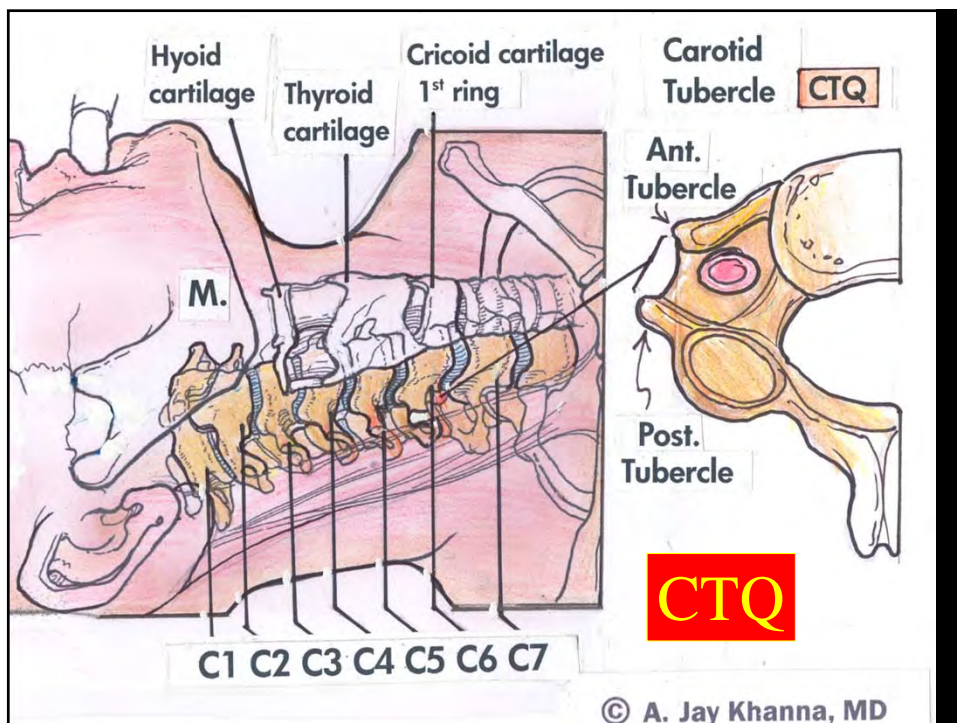
II. Intradural-Extramedullary

- | | | | |
|----|--|----|------------|
| A. | Nerve sheath tumors
(Neurofibroma > Schwannoma) | D. | Lipoma |
| B. | Meningiomas | E. | Epidermoid |
| C. | Subarachnoid seeding
(Metastases) | F. | Dermoid |

III. Intramedullary

- A. Ependymoma
B. Astrocytoma
C. Hemangioblastoma

Walker HS. *Radiographics* 1987;7(6):1129-1152.



Relational Anatomy: Cervical Spine

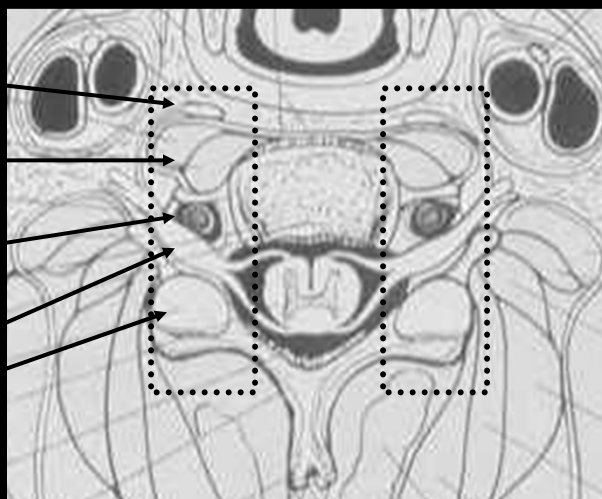
Sympathetic chain

Longus colli

vertebral Artery

Cervical nerve root

Lateral mass



Anterior Approach C-Spine

- Recurrent laryngeal nerve
 - Left -- Aortic Arch
 - Right – Subclavian artery
 - Supplies vocal muscles
- Horner's syndrome
 - [Inferior Ganglion of Sympathetic Chain]*
 - Ptosis,
 - Miosis
 - Facial Anhidrosis

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Anterior Approach C-Spine

Laryngeal Nerves in ACDF

- Superior laryngeal nerve
 - traction in upper cervical surgery
 - high note phonation
 - no vocal cord paralysis
- Recurrent laryngeal nerve
 - vocal cord paralysis on the side of injury
 - hoarseness
 - aspiration
 - can compensate partially for phonation

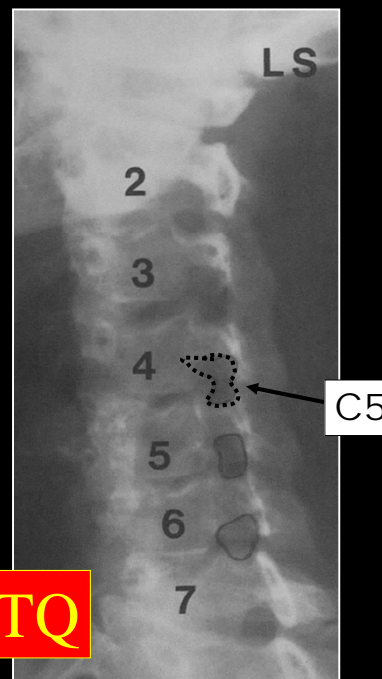
Oblique Anatomy

- 7 cervical vertebra
- 8 cervical roots

The lower numbered root exits the numbered neuroforamen

Therefore, the C5 nerve root exits the C4-C5 neuroforamen

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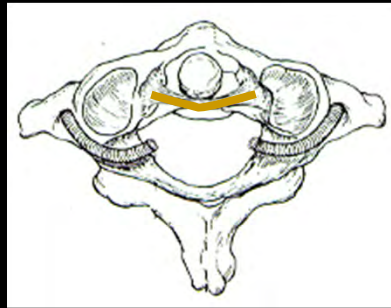
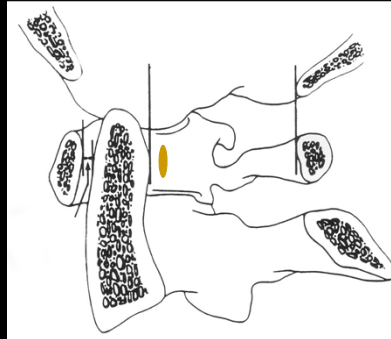


Atlantoaxial Relational Anatomy

- Relationship # 1
 - Ring of C1
 - Dens
 - Transverse Ligament

Transverse ligament
helps provide C1-C2 stability

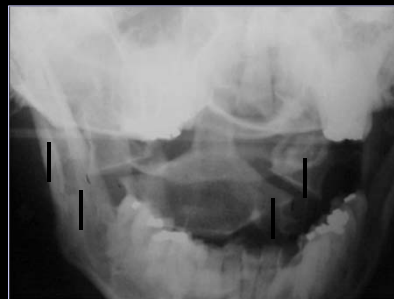
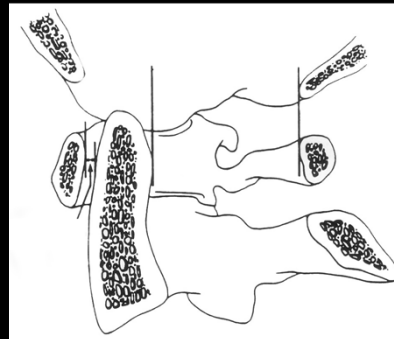
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Applied Biomechanics

- Lateral C-Spine
 - Normal ADI
 - 3.5 mm in Adults
 - 4.0 mm in Children
- Open mouth
 - Normal lateral mass overhang
 - 6.9 mm total overhang

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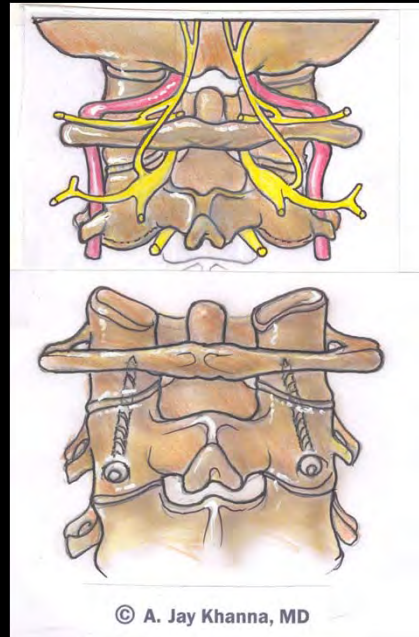


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Clinical Correlate

- Dissection on the ring of C1 should be < 1.0 cm from the midline
- Atlantoaxial settling in rheumatoid patients can compress the C2 nerve causing base of the skull pain
- C2 nerve root is at risk during placement of the C1-2 transarticular screw

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Applied Anatomy

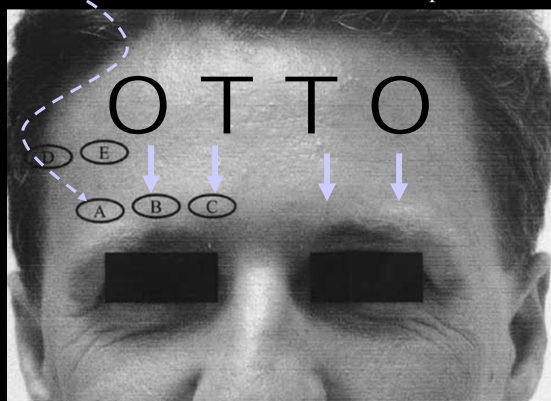
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Halo Application

Structures at Risk

SAE spine 2003

- A-- insert PIN here
- B-- Supraorbital nerve
- C-- Supratrochlear nerve
- D-- Temporalis
- E-- Above the equator



Thoracotomy: Anatomy

- Dissect along SUPERIOR aspect of rib
 - (avoid neurovascular bundle)
- Artery of Adamkiewicz (T9-T11)
- Thoracic Duct
 - Upper thoracic spine
 - Left side of esophagus
 - Behind carotid sheath

CTQ

Miller, MD. Review of Orthopaedics, 5th Edition, 2008.

Anterior Lumbar: Anatomy

- L4-5
 - Ligation of Iliolumbar Vein often required
- Superior Hypogastric Plexus
 - Retrograde Ejaculation
 - Sexual Dysfunction

CTQ

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Surgical Approach

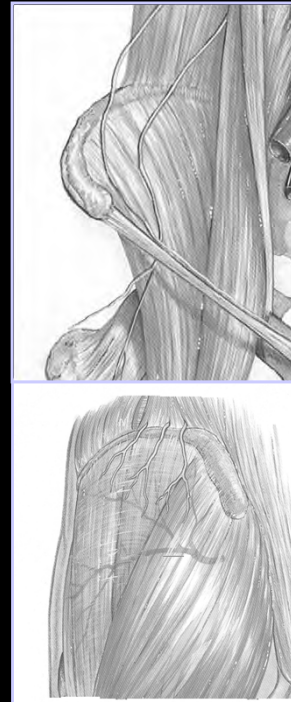
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- **Genitofemoral n/sympathetic plexus**
 - Ventral surface of psoas muscle
- **Ilioinguinal & iliohypogastric nerves**
 - Superior br. of lumbar plexus
 - Emerge upper lateral border of psoas traveling toward the quadratus lumborum
- **Obturator & femoral nerves**
 - Deep and lateral to the psoas muscle
 - Not visualized during the approach



High-Yield Fact

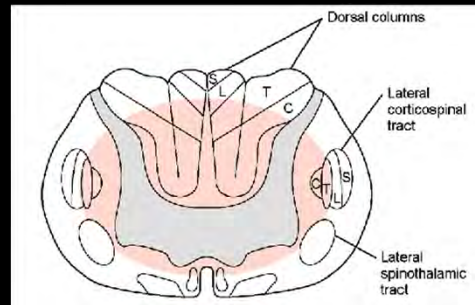
- Structures at risk during graft harvest?
 - Anterior **CTQ**
 - Lateral femoral cutaneous n.
 - Anterior thigh numbness
 - Posterior **CTQ**
 - Cluneal n.
 - 8 cm lateral to PSIS
 - Buttock numbness
 - Superior gluteal artery



Spinal Cord

- Dorsal Columns
 - Deep Touch
 - Proprioception
 - Vibratory Sensation

CTQ

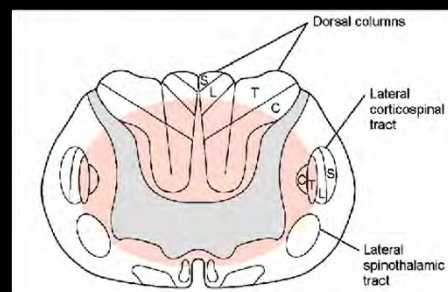


Browner, Jupiter. Skeletal Trauma, 2nd Edition, 1998.

Spinal Cord

CTQ

- Lateral Spinothalamic Tract
 - Pain and Temperature
 - Site of Chordotomy for Intractible Pain
- Lateral Corticospinal Tract
 - Voluntary Muscle Contraction



Browner, Jupiter. Skeletal Trauma, 2nd Edition, 1998.

Spine

Biomechanics:

A Basic Primer Course

*American Academy of Orthopaedic Surgeons
Review Course*

Frank H. Shen, M.D.

Professor

Department of Orthopaedic Surgery
University of Virginia

Biomechanical Studies of C1-C2 Posterior Techniques

	Flexion	Extension	Rotation
Modified Gallie	Good	Poor	Poor
Brooks	Good	Better	Better
Transarticular Screws	Best	Best	Best



Oh, by the way...

2 Random Lumbar Concepts for the Boards

Anterior: Shear at L5-S1 is bad

Posterior: Lumbar distraction is bad

CTQ

Spinal Deformity

L5-S1 Spondylolisthesis

- Q: Choosing between L5-S1 vs. L4-S1
- A: In low grade slips
 - Grade I / II (0-50%) slip
 - Fairly horizontal L5-S1
 - Fuse from L5-S1 only
- A: In high grade slips
 - Grade III/IV (51-100%) slip
 - L5-S1 often fairly vertical
 - Fuse from L4-S1

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Cervical Spine Trauma

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A. Jay Khanna, MD

The Johns Hopkins Medical Institutions

Department of Orthopaedic Surgery

Baltimore, Maryland

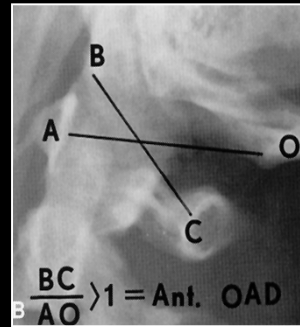
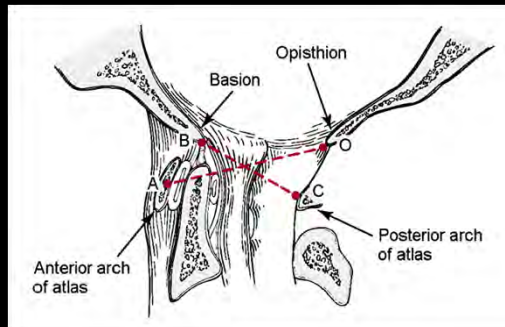


Pseudo-Subluxation

- C2 On C3 — **CTQ**
- Check Spinolaminar Line
- C2 WITHIN 2mm OF LINE



Atlanto-Occipital Dislocation

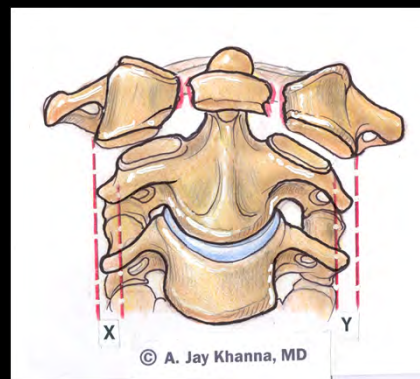


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Browner, Jupiter. Skeletal Trauma, 2nd Edition, 1998.

C1 (Atlas) Fracture

- < 6.9 mm
→ Halo Vest x 3 Months
- > 6.9 mm
– Treatment Controversial
 1. Traction x 6-8 weeks f/b 6 weeks Halo
 2. Halo Vest Only
- Flex-Ex after Halo Removed
–Tx C1-C2 Instability
(> 5 mm) with Fusion



CTQ

Tay, Eismont. OKU: Spine 2, 2002

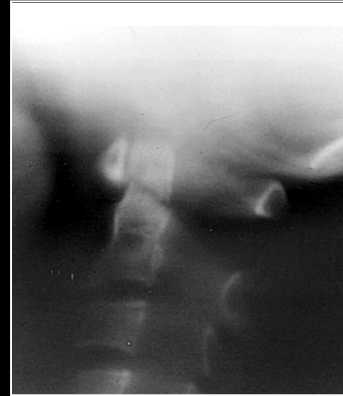
Browner, Jupiter. Skeletal Trauma, 2nd Edition, 1998.

Odontoid Fracture

Type II (60%)

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- @ junction of odontoid & C2 body
- nonunion rate is higher-- related to:
 - angulation > 10 degrees
 - displacement > 5 mm
 - age > 60-65 years (OKU: 40 years)
 - smoking
- nonunion rate reported as high as 88% (average 33%)
- associated w/ C1 Fx in 16%



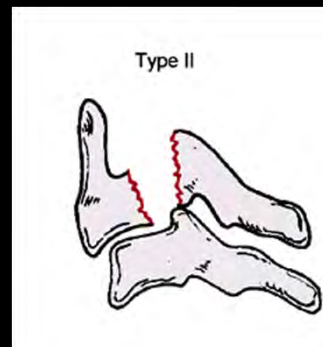
Tay, Eismont. OKU: Spine 2, 2002
Browner, Jupiter. Skeletal Trauma, 2nd Edition, 1998.
Miller, MD. Review of Orthopaedics, 5th Edition, 2008.
An H. Principles & Techniques of Spine Surgery. 1998.

C2 Isthmus (Hangman's) Fracture

-Type II

- Tx: Closed extension traction if > 6 mm translation & halo immobilization x 12 weeks
- Nonunions treated w/ anterior C2-3 fusion or posterior C1-3 fusion
- Acceptable reduction
 - = < 4 mm translation &
 - < 10° angulation

CTQ



Miller, MD. Review of Orthopaedics, 5th Edition, 2008.
Browner, Jupiter. Skeletal Trauma, 2nd Edition, 1998.

C2 Isthmus (Hangman's) Fracture

-Type IIA

-severe angulation with minimal translation

-Tx: extension and compression halo treatment for 6 weeks and fusion as necessary.



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Miller, MD. Review of Orthopaedics, 5th Edition, 2008.
Browner, Jupiter. Skeletal Trauma, 2nd Edition, 1998.

C3-C7 Facet Joint Injuries

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UFD



BFD

Browner, Jupiter. Skeletal Trauma, 2nd Edition, 1998.

Degenerative Cervical Spine

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The Johns Hopkins Medical Institutions

Department of Orthopaedic Surgery
Baltimore, Maryland



Cervical Stenosis

- Congenital
- Acquired
 - Traumatic
 - Degenerative
- Absolute Stenosis
 - Anteroposterior canal diameter (< 10 mm)
- Relative Stenosis
 - 10-13 mm



Cervical Spondylosis: Signs and Symptoms

- Degenerative discogenic neck pain
 - insidious onset of neck pain w/o neurologic signs or symptoms
 - exacerbated by motion
- Occipital Headache Common
- Findings may overlap d/t intraneural intersegmental connections of sensory nerve roots.
- **Lower nerve root at a given level is usually affected (ie. C6 nerve root at C5-6)**

CTQ

ACDF: Complications

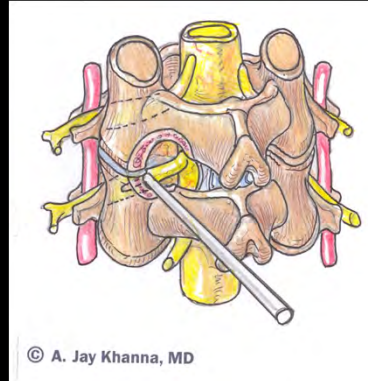
CTQs

- Fact: Recurrent Laryngeal Nerve at Risk
 - Lower Levels (C6-7) → Increased Risk
 - Uncertainty: Difference Left vs. Right Approach
- Increased Dysphagia Risk at higher levels (C3-4)
- Increased risk of airway obstruction with multiple levels
- Nonunion Rate: 2-10%
 - Increasing Rate with Increased # of Levels

Posterior (“Keyhole”) Foraminotomy

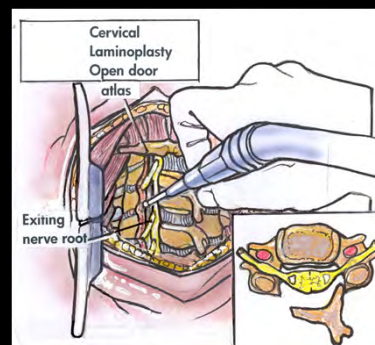
- Preserve >50% of Facet Joint
- Elevate Nerve Root Superiorly
- Risk: Air Embolism

CTQ



Cervical Spondylosis: Treatment

- **Laminoplasty**
 - Commonly used for OPLL
 - Decreases incidence of instability associated w/ multilevel laminectomy
 - Overall alignment must be lordotic for this technique to be successful



CTQ

- KYPHOTIC Patient
→ Don't pick Laminoplasty

Heller JG. OKU: Spine 2, 2002
Miller, MD. Review of Orthopaedics, 5th Edition, 2008.

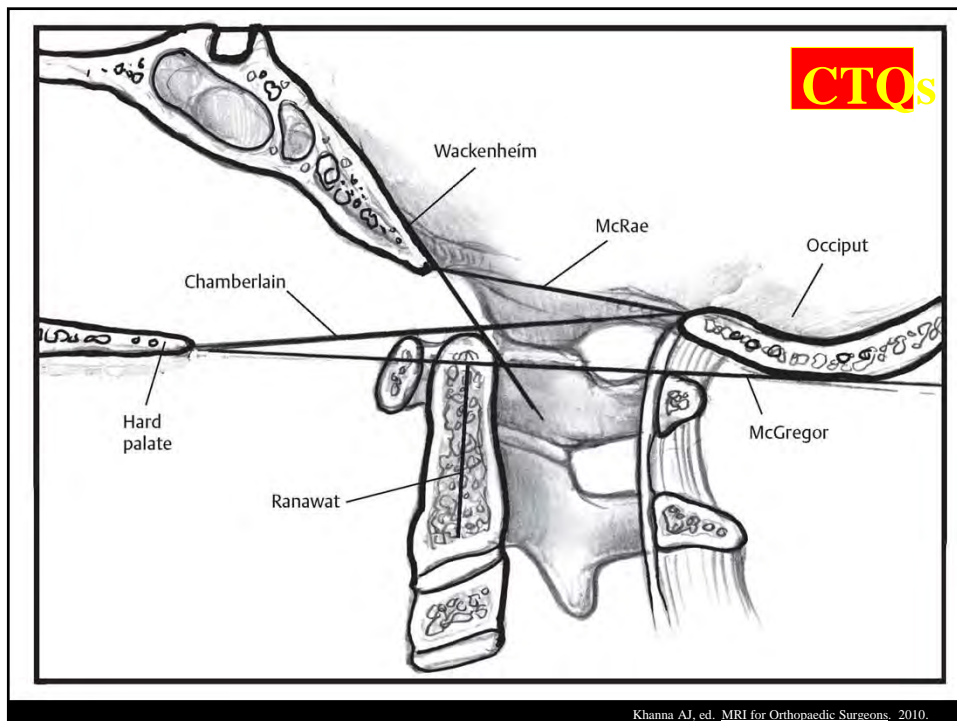
Neurologic Impairment with RA

Classified by Ranawat

CTQ

- I Subjective Paresthesias
- II Subjective Weakness, UMN Findings
- III Objective Weakness, UMN Findings
(A= Ambulatory, B= Nonambulatory)

Pellicci PM, Ranawat CS. JBJS 1981.
Casey AT, et al. J Neurosurgery, 1996.



RA: Lower Cervical Spine

- Involvement in 20% of cases
- Joints of Luschka and facet joints affected by RA
 - thus, subluxation can occur at multiple levels
- Lower C-Spine involvement more common in:
 - males
 - steroid use
 - seropositive RA
 - patients with rheumatoid nodules
 - patients with severe RA

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Miller, MD. Review of Orthopaedics, 5th Edition, 2008.

Ankylosing Spondylitis

- HLA-B27
- Acute Anterior Uveitis
- Renal Amyloidosis
- Cardiac Conduction Disturbances
- Cardiac Valve Dysfunction
- **MRI Examination Critical–
ESPECIALLY IN TRAUMA
PATIENTS**

CTQs

Fischgrund, JS. OKU: Spine 2, 2002.

Thoracolumbar Trauma

American Academy of Orthopaedic Surgeons

Frank H. Shen, M.D.

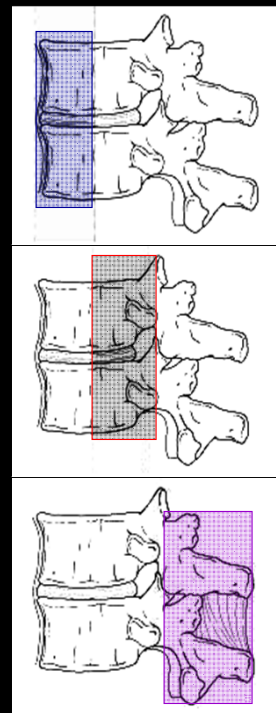
Department of Orthopaedic Surgery
Division of Spine Surgery
University of Virginia School of Medicine

Denis Classification

Three column model

- Anterior
 - ALL, anterior ½ annulus / vertebral body
- Middle
 - PLL, posterior ½ annulus / vertebral body
- Posterior
 - Posterior bony arch
 - Posterior ligamentous complex

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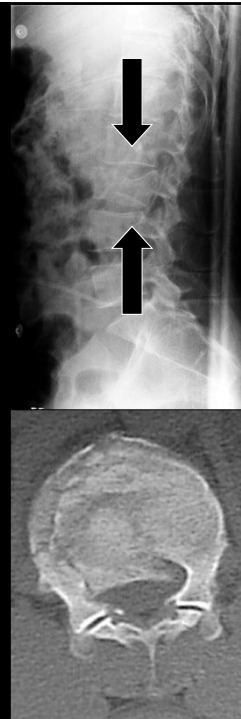


Denis Classification

Burst Fractures

- **Mechanism:**
 - Axial compression
- **Column involvement**
 - Anterior column involved
 - Middle column involved
- **+/- Posterior column**
 - Look for lamina fractures on CT scan
 - Possible dural tear / nerve entrapment

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Denis Classification

Burst Fractures

- **Surgical Indications**
 - Neurologic deficit
 - Significant Loss of Alignment:
 - > 30 degrees jxn kyphosis
 - > 50% loss of anterior height
 - ???> 50% canal compromise
- **Example:**
 - Burst fracture in patient that is neurologically intact with minimal deformity
 - Extension bracing !!!!

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Traumatic Spinal Conditions

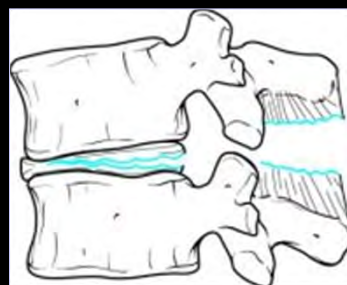
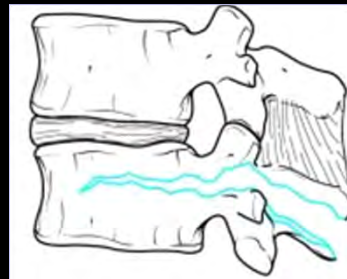
“Low” Lumbar Burst Fx (L5)

- Conservative treatment
 - Roots at this level
 - No conus to worry about, but cauda equina still possible
- Kyphosis <20 degrees
 - Can't accept as much as at T/L jxn (30 degrees)
 - Majority of lumbar lordosis is at L4 to sacrum
 - T12-L3: 25% of lumbar lordosis
 - L4-sacrum: 75% of lumbar lordosis

Denis Classification

Flexion-Distrraction

- No translation
- Associated intra-abdominal injuries
 - Ileus
 - Made worse by extension bracing!!!
- Treatment
 - Bony injury-bracing
 - Ligamentous injury—surgery
 - Posterior Tension Band



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Incomplete Spinal Cord Syndromes

- Brown-Sequard
 - Stabbing. Penetrating injury
 - Ipsilateral motor. Contralateral pain and temp
- Central cord-common
 - Elderly. Hyperextension injury
 - Involvement of UE > LE
- Anterior cord
 - Vascular injury
 - Anterior thoracic surgery. ?Artery Adamkiewicz
 - Motor loss. Preserved dorsal column-proprioception
- Posterior cord-rare
 - Motor intact. Loss of proprioception

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High Yield Facts

- | | |
|-----------------------------|----------------|
| • Most common | Central Cord |
| • Least common | Posterior Cord |
| • Prognosis for ambulation | |
| – Best | Brown-Sequard |
| – Worst | Anterior Cord |
| • Mechanism | |
| – Vascular injury | Anterior Cord |
| – Penetrating injury | Brown-Sequard |
| – Hyperextension in elderly | Central cord |
| • Involvement: | |
| – Upper > Lower | Central Cord |
| – Lower > Upper | Anterior Cord |

CTQ

High Dose Steroids

- Load
 - 30 mg/kg iv methylprednisolone bolus for 1 hr
- Infuse
 - 5.4 mg/kg iv for 23 hrs if initiated within 3 hours
 - 5.4 mg/kg iv for 48 hrs if initiated from 3 to 8 hours
- Aside: *Becoming more and more controversial*

Neurogenic versus Spinal Shock

- Neurogenic shock
 - SCI to lower cervical or upper thoracic
 - Loss of sympathetics
 - Hypotensive and bradycardia
- Spinal shock
 - Initial period after spinal cord injury
 - Metabolic derangement not necessarily structural
 - Unable to assess if spinal cord injury is complete or incomplete.
 - Bulbocavernosus signals end of spinal shock

CTQ

CTQ

Thoracic and Lumbar Degenerative Disease

American Academy Orthopaedic Surgery

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Professor

Department of Orthopaedic Surgery
University of Virginia School of Medicine

General Comments

Risk Factors LBP

- 30-50 y.o. Males
- Job occupations
 - Heavy lifting, twisting, stressful
 - Job Dissatisfaction
- Lower income
- Cigarette smoking
- Prolonged exposure to vibrations 4-5 Hz
- L4-5 and L5-S1 make up 90% of LHD
- L3-4 next most common



Physical Examination

- Waddell's signs for nonorganic pathology
 - Tenderness to light touch
 - Pain in a nonanatomic distribution
 - Loss of findings during distraction
 - Overreaction

CTQ

Straight Leg Raise (SLR)

- Supine. Many variations exist
- Evaluating L4, L5 and S1 nerve
- Maximal tension at 35 – 70°

Contralateral SLR

CTQ

- More specific for HNP, esp for axillary HNP

Femoral Tension Sign

- Prone/lateral position. Hip extension, knee flexion.
- Evaluating L2, L3, and L4 nerve
- Anterior groin, thigh or medial leg pain

Imaging Studies

MRI

- Herniated Disc
 - 25-37% abnormal disc in asymptomatic subjects
 - MRI with Gadolinium best imaging study for recurrent HNP
- Discogenic Back Pain
 - Decreased signal (T2 weighted images)
 - High intensity zone (HIZ)
 - Increased signal intensity within posterior annulus on T2

CTQ

MRI

- Correlating imaging with clinical findings
 - **False-positive MRI scans are common**
 - 35% of patients < 40 y.o.
 - 93% of patients > 60 y.o.

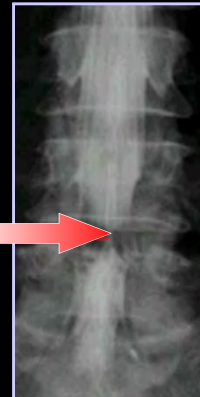
CTQ

- | | |
|--------------------------------|-----|
| • Objective neurologic | 55% |
| • “+” SLR | 66% |
| • “+” SLR with “+” imaging | 86% |
| • “+” neurologic, SLR, imaging | 95% |

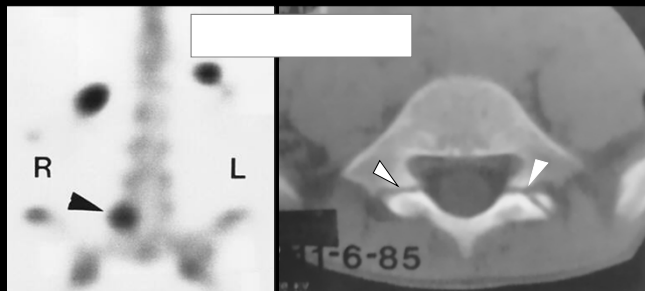
Additional Imaging

- CT Myelogram
- SPECT **CTQ**
 - Most sensitive method for detecting isthmic spondylolisthesis

Spinal Stenosis



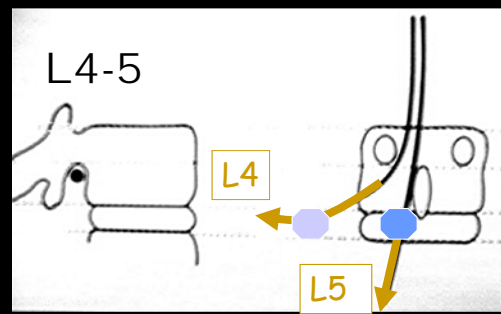
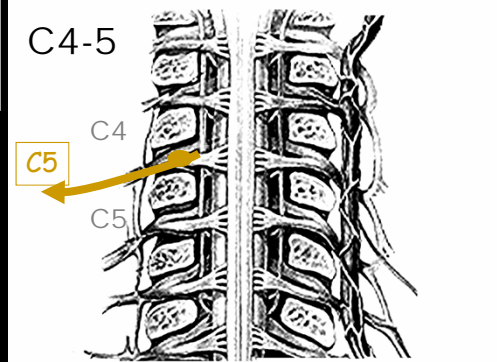
- Bone scan
 - Infections
 - Tumor
 - Pars defects



High Yield Fact

- Herniated C4-C5 disc
 - C5 nerve
- Herniated L4-L5 disc
 - Posterolateral
 - L5 nerve root
 - Far lateral
 - L4 nerve root
 - Foraminal stenosis
 - L4 nerve root

CTQ



Lumbar HNP

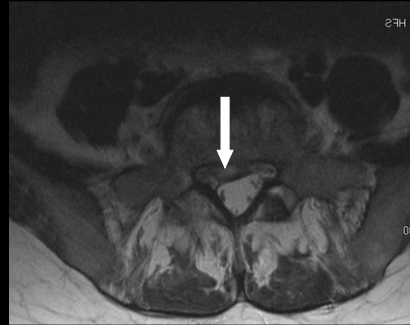
Posterolateral

- More common
- Traversing nerve root affected

CTQ

Far Lateral

- Exiting nerve root affected



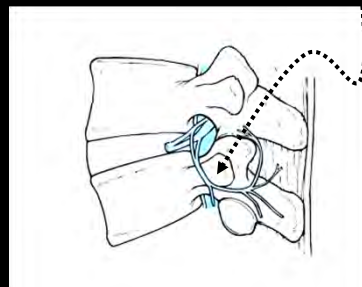
High-Yield: Axial Back Pain

Intradiscal Pressure



CTQ

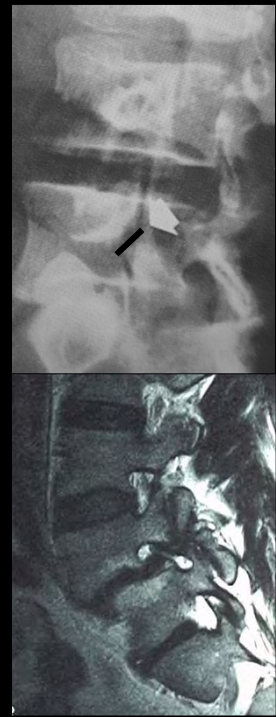
Medial branch of dorsal primary rami and sinuvertebral nerve



High-Yield Facts

Isthmic Spondylolisthesis

- Pars defect
- “Scotty dog” sign
 - See pars defect on OBLIQUE x-ray
- Exiting nerve root affected **CTQ**
 - Fibrocartilaginous reparative process underneath the pars
 - L5-S1 isthmic spondylolisthesis affects L5 nerve root



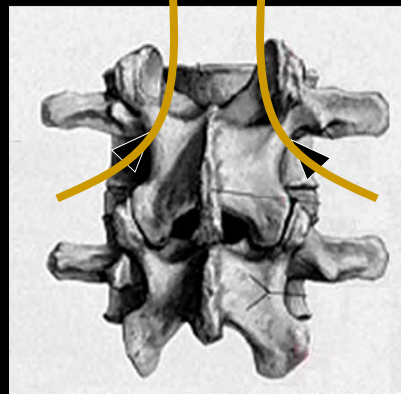
High-Yield Facts

Iatrogenic Spondylolisthesis

Causes

CTQ

1. Iatrogenic removal of the pars
2. Unilateral total facetectomy
(1 x 100%=100%)
3. Bilat >50% partial facetectomy
(2 x 50%=100%)



Central Stenosis

- Neurogenic claudication:
 - Heaviness/cramping of calves
 - Sit/flexion relieves Sx (opens up spinal canal)
 - Different from vascular claudications
 - Grocery cart sign

CTQ

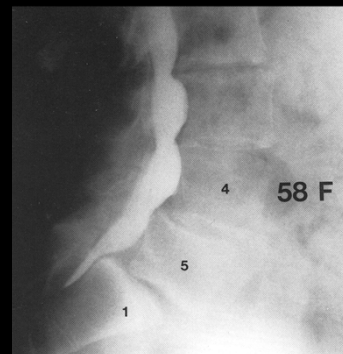
Lateral Stenosis

- Radicular symptoms
 - Nerve root canal (lateral recess stenosis)
 - Intervertebral foramen (neuroforaminal stenosis)

Putting it all together

Spondylolisthesis from Hell

- OITE: 60 y.o. LBP and leg pain. Degenerative spondy L4-L5. Isthmic spondy L5-S1. Roots involved?
- L5 !!!!
- Degenerative spondy L4-5
 - L4 has exited already
 - Lateral recess stenosis (sublux inf articular facet of L4) → L5 nerve root
- Isthmic spondy L5-S1
 - Bony/fibrous reparative tissue of pars and cephalad bulge of L5/S1 disc
 - Foraminal stenosis of L5 → L5 nerve root



CTQ

Lumbar Disc Disease

Cauda Equina Syndrome

Bowel and bladder difficulties

Incontinence or frequency

CTQ

Impotence

Perianal/saddle numbness

Diminished rectal tone

Typically motor deficits also present

Lumbar Disc Disease

Cauda Equina Syndrome

Uncommon

Recognition is vital

CTQ

Consequences can be disastrous

Spontaneous recovery uncommon

Prompt surgical intervention recommended

Thoracic Disc Disease

- Imaging
 - As with lumbar degenerative disease
- Treatment
 - If no myelopathy then nonoperative
 - Surgical
 - Variety of approaches
 - Laminectomy is the wrong answer
 - High rate associated with paralysis
 - Poor results

CTQ

Spinal Cord Injury

AAOS Board Review and Preparation Course

A. Jay Khanna, MD

The Johns Hopkins Medical Institutions

Department of Orthopaedic Surgery
Baltimore, Maryland



Neurologic Status: Incomplete or Declining

- Steroids best if within 3 hours
- Next best within 8 hours
- Emergent intervention

CTQ

Spinal Shock

- Occurs immediately after spinal cord injury
- Spinal cord nervous tissue dysfunction due to physiologic reasons rather than structural damage
- Results in: flaccid paralysis, hypotonia, areflexia
- Bulbocavernosus reflex (BCR) absent during spinal shock
- When BCR returns--> spasticity, hyperreflexia, clonus

CTQ

Neurogenic Shock

- Results from loss of autonomic reflexes
 - hypotension
 - bradycardia
- Attributed to sympathetic outflow disruption (T1 - L2) and unopposed vagal tone
- Treatment
 - invasive monitoring fluids, vasopressors
- May coexist w/ hypovolemia



Tay, Eismont. OKU: Spine 2, 2002
Miller, MD. Review of Orthopaedics, 5th Edition, 2008.

Spinal Cord Injury: Autonomic Dysreflexia

- Sudden Hypertension, Pounding Headache, Flushing, Profuse Sweating, Blurred Vision, Nasal Congestion
- Potentially catastrophic hypertensive event
- Can occur w/ injuries above T5
- Usually caused by obstructed urinary catheter or fecal impaction



Freedman MK, Fried GW. P&P of Spine Surgery, 2003.
Miller, MD. Review of Orthopaedics, 5th Edition, 2008.

Spinal Cord Injury

Functional Level Determined By:

1. Most Distal Intact Functional Dermatome (Sensory Level)
2. Most Distal Intact Motor Level
> Grade 3-4/5 provided that next rostral level is 5/5

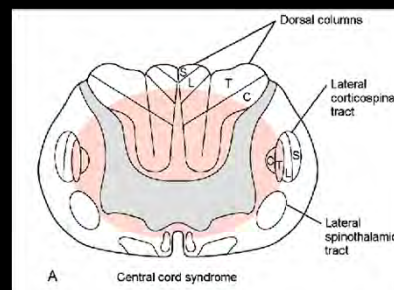


CTQ

Apple DF. OKU: Spine 2, 2002.
Miller, MD. Review of Orthopaedics, 5th Edition, 2008.

Central Cord Syndrome

- Most common
- Usually secondary to C-Spine extension in elderly w/ pre-existing stenosis
- Upper extremities more affected than lower
- Motor and sensory loss
- Perianal sensation preserved

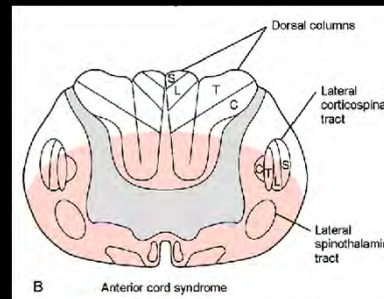


CTQ

Tay, Eismont. OKU: Spine 2, 2002
Browner, Jupiter. Skeletal Trauma, 2nd Edition, 1998.

Anterior Cord Syndrome

- Less common
- Usually flexion-compression mechanism
- Lower extremities more affected than upper
- Posterior column sensory pathways preserved
- **Worst prognosis**
(16% have neuro improvement)

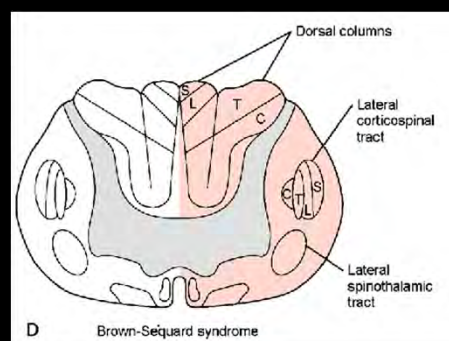


CTQ

Tay, Eismont. OKU: Spine 2, 2002
Miller, MD. Review of Orthopaedics, 5th Edition, 2008.
Browner, Jupiter. Skeletal Trauma, 2nd Edition, 1998.

Brown-Sequard Syndrome

- Penetrating injury
- Ipsilateral motor loss
- Contralateral pain and temperature loss
- Ipsilateral joint position, vibration and tactile discrimination loss.
- **Best prognosis** for segmental recovery
(90% of Patients)

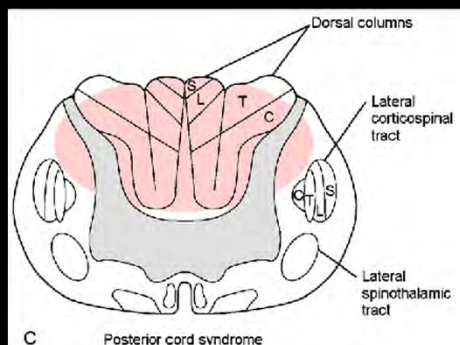


CTQ

Tay, Eismont. OKU: Spine 2, 2002
Browner, Jupiter. Skeletal Trauma, 2nd Edition, 1998.

Posterior Cord Syndrome

- Rare
- Preservation of motor function
- Loss of sensory function
 - joint position
 - vibration
 - deep pressure
- Ambulation possible only with visual feedback

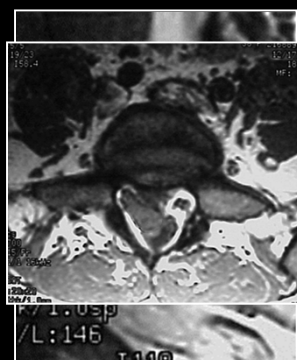


CTQ

Tay, Eismont. OKU: Spine 2, 2002
Browner, Jupiter. Skeletal Trauma, 2nd Edition, 1998.

Cauda Equina Syndrome

- Severe low back pain
- Unilateral or bilateral sciatica
- Saddle Anesthesia
- Motor Weakness
- Loss or reduction in LE reflexes
- Varying degrees of bladder or rectal dysfunction
- Relatively rare
- Often missed



Lemma et al. P&P of Spine Surgery, 2003.

Cauda Equina Syndrome

- Immediate MRI or CT myelography for evaluation
- May consider urodynamic studies
- Emergent/urgent surgery for decompression
 - No minimally invasive procedures
 - Standard mid-line incision and wide decompression
- Outcomes better with surgery <48 hours than >48 hours

Lemma et al. P&P of Spine Surgery, 2003.
Ahn UM et al. Spine, 2000.
Kostuik JP, et al. JBJS, 1986.

GSW to Spinal Cord/Spine

- Nonoperative treatment unless direct passage through esophagus or colon
- Or progressive neurologic deterioration w/ proven neurologic compression w/ bullet, bony fragments or hematoma



Tay, Eismont. OKU: Spine 2, 2002
Miller, MD. Review of Orthopaedics, 5th Edition, 2008.

Infections of the Spine

American Academy of Orthopaedic Surgeons

Frank H. Shen, M.D.

Professor

Department of Orthopaedic Surgery
University of Virginia School of Medicine

Presentation: Osteodiscitis

Symptoms

- Based on acuity (acute, subacute, or chronic)
- **Pain** most common
- Only ~ 50% had fever **CTQ**
- Clinically significant abscess is uncommon
 - C-spine: retropharyngeal → mediastinum
 - T-spine: paraspinous/retromediastinal
 - L-spine: psoas abscess
- Abscess from spine can drain almost anywhere

Presentation

Laboratory Studies

- ESR/CRP
 - Elevated > 90%
- WBC
 - Elevated in only 42% of cases
 - Typically normal in chronic cases
- Blood cultures
 - Positive in 24% of patients with pyogenic infections

CTQ

Empirical Treatment

- Parenteral Abx
 - Four to six weeks
 - High failure rates with treatment < 4 weeks
- Oral Abx
 - ESR/CRP- reasonable indicators of response
 - Consider repeat biopsy if ESR/CRP does not decrease
- Consider orthosis for immobilization
 - Pain control
- Address co-morbidities
 - Nutrition, hypoxia, metabolic deficit, diabetes
 - Treat any underlying infections

CTQ

CTQ

Pyogenic infections

Prognosis

- **Recurrent infection**
 - Up to 25% of cases
 - Lower if treated >28 d with appropriate antibiotics
- **Neurologic deficits** (overall <15%)
 - Worse prognosis:
 - Patients with *increased age*
 - More *cephalad lesion*
 - Diabetes, RA, immune deficiency disorders
 - Root lesions do better (even if treated nonoperatively)

CTQ

Tuberculosis Spondylitis

Differences from Pyogenic Infections

1. Pathologic changes usually take longer to develop
2. Discs relatively resistant and may be preserved despite extensive bone loss
3. Large Paraspinal Abscesses more common
4. Frequently associated with greater deformity

CTQ

Epidural Abscess

- Incidence increasing
 - 7% spine infxns have epidural abscess
- Hematogenous
- Contiguous spread
 - Discitis
 - Vertebral osteomyelitis
- Direct inoculation
 - Intraoperative
 - ESI
 - Lumbar puncture
- Patients are more **systemically ill** than vertebral osteomyelitis patients

CTQ



Epidural Abscess

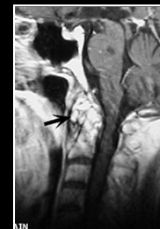
Medical Management

- Antibiotic therapy alone for epidural abscess
 - **Rarely indicated**
- CTQ
- Poor surgical candidate
 - ? No significant neurologic deficit
 - ? Significant multiregional spinal canal involvement
 - ? Complete neurologic deficit for > 3 days

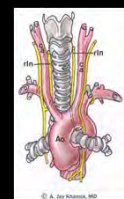
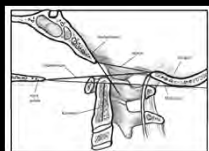
Summary

- Establish the diagnosis!
 - MRI with gadolinium
 - Percutaneous biopsy (off antibiotics)
- Identify medical vs surgical management
 - Discitis / Osteomyelitis
 - Typically MEDICAL
 - Not septicemic
 - No abscess
 - No deformity
 - Epidural abscess
 - Typically SURGICAL

CTQ



Thank You



Spine Hi Yield Review

AAOS Board Review Course

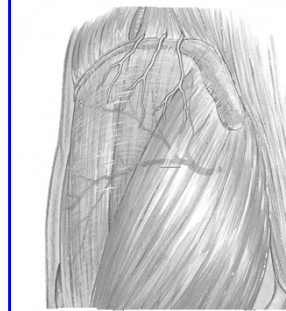
Frank Shen, M.D.
Warren G. Stamp Professor of Orthopaedic Surgery
Division Head, Division of Spine Surgery
Co-Director, Spine Center
University of Virginia

Anatomy

High Yield Facts



- Structures at risk during graft harvest?
 - Anterior
 - Lateral femoral cutaneous n.
 - Anterior thigh numbness
 - Posterior
 - Superior cluneal nerve.
 - 8 cm lateral to PSIS
 - Buttock numbness
 - Superior gluteal artery



Pure Anatomy



- Artery of Adamkiewicz
 - Left side
 - Posterior intercostal artery
 - T8-T12 (T9-11)
 - Its relevance to iatrogenic spinal cord problems is still uncertain.
- Thoracic duct
 - Left side
 - Posterior to structures of carotid sheath
- Carotid tubercle
 - C6

High-Yield Facts



- Horner's
 - Preganglionic C8-T1
 - Ptosis (drooping eyelid)
 - Miosis (constricted pupil)
 - Anhidrosis (absence of sweat)
- Anterior cervical plate
 - Lies posterior to the trachea and esophagus

High-Yield Vertebral Artery



- Relational Anatomy
 - Posterior to longus colli
 - Anterior to lateral mass
- Trauma: Bilateral C5/6 facet dislocations
 - Vertebral artery injury
 - Diplopia, vertigo, tinnitus
- C1-C2 anatomy
 - 1.5 cm lateral from posterior midline dissection
 - 1.0 cm lateral for superior

Relational Anatomy: Cervical Spine



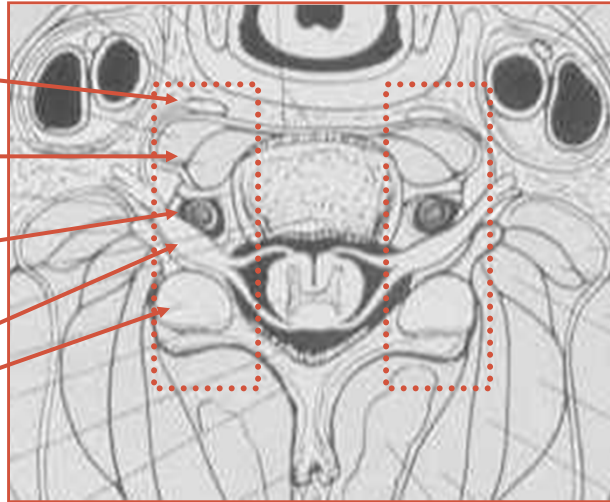
Sympathetic chain

Longus colli

vertebral Artery

Cervical nerve root

Lateral mass



Greater Occipital Nerve



- Anatomy
 - C2 nerve root
 - Exits between C1 and C2
- Rheumatoid arthritis
 - Compression can cause base of the skull pain
- Trauma
 - At risk during C1-C2 transarticular screws placement

Retroperitoneal Lumbar Approach



- Structures at risk
 - Ureter lies in peritoneal cavity
 - Genitofemoral nerve and Sympathetic chain at risk
 - Superior Hypogastric plexus

Retroperitoneal Lumbar Approach



- Vascular anatomy of the anterior lumbar spine
 - IVC to the right of descending Aorta in lumbar spine
 - Bifurcation of Great Vessels are at L4/5 disc space
 - Iliolumbar vein at level of L5
 - Segmental vessels at level of mid body

Sexual Dysfunction after Anterior Lumbar Surgery



- Erectile dysfunction
 - Usually nonorganic.
 - Parasympathetics deep in the pelvis at S2-3 and S3-4
 - Erectile function not affected by sympathetic injury
- Retrograde ejaculation
 - Superior hypogastric sympathetic plexus injury
 - Anterior surface crossing at L4-5 and L5-S1 level

“Point and Shoot”

Degenerative Spine

Herniated Disc



- Management HNP
 - Conservative measures initially
 - Pain without significant motor deficit.
 - Painless Great Toe weakness
 - Surgery
 - Failed conservative > 3 mos
 - Progressive neurologic deficit
- Herniated C4-C5 disc
 - C5 nerve
- Herniated L4-L5 disc
 - Posterolateral L5 nerve root
 - Far lateral L4 nerve root
 - Foraminal stenosis L4 nerve root

Spinal Stenosis



- Neurogenic claudication without spondylolisthesis
 - Decompressive laminectomy
- Neurogenic claudication with degenerative slip
 - Laminectomy with posterolateral fusion +/- instrumentation
- Iatrogenic instability
 1. Iatrogenic removal of the pars
 2. Unilateral total facetectomy (1 x 100%=100%)
 3. Bilateral partial facetectomy >50% (2 x 50%=100%)

Word Association

Cauda Equina

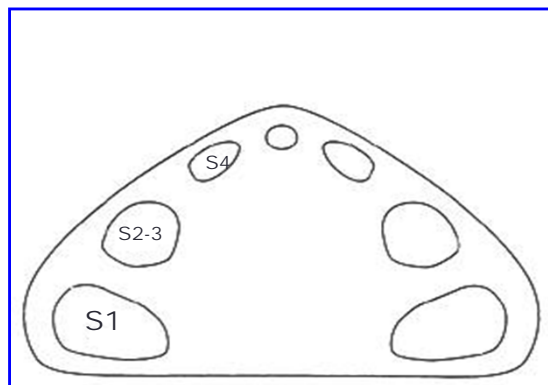


- Abdominal bloating
- Urinary retention
- Saddle anesthesia
- Bladder function = S2, S3, and S4 nerve roots.
- Decreased rectal tone and urinary retention
- Urgent surgical decompression

Sacral Root Anatomy



Posterior



Anterior

High Yield Facts



- Conus medullaris syndrome
 - Conus ends at level of L1 typically
 - Typically injury at T12-L1 or T11-T12
 - Isolated loss of bowel and bladder function
- Cauda equina syndrome
 - Injury at the lumbar levels
 - Large HNP, tumor, severe stenosis
 - Some degree of lower extremity

Degenerative Spinal Conditions

Mechanical axial LBP

- Make sure there are no red flag questions
- Conservative measures if <4 wks
 - Imaging not indicated if <4 weeks of Sx
- Imaging -- start with plain films
- Think rheumatologic stuff
 - esp if they give you ESR, titers, etc
- Discogram
 - Concordant pain at one level best indicator for success with surgical fusion

Dural Tears



- Management of intraoperative tear.
 - Primary repair whenever possible.
 - Water tight closure.
 - Bed rest 48 hours
 - No drain necessary
- Management of post-operative tear.
 - Subarachnoid drain, Abx, bed rest
 - If persists greater than 3-4 days then surgical re-exploration
- Post-op nausea on PCA after Lumbar disc surgery
 - Don't forget about dural tear as a possibility

Spinal Deformity

Harrington Instrumentatio



- Flatback
- Lumbar distractive instrumentation
- Sagittal malalignment
- Loss of lumbar lordosis
- Positive sagittal balance

Classic Images: Spondylolisthesis and Spondylolysis



Isthmic Spondylolisthesis



- Pars (interarticularis) defect
- Scotty dog
- 5% of the general population
- Progression uncommon
- Familial predisposition
- SPECT- Most sensitive test for isthmic spondy
- Repetitive Hyperextension
- Football player with low back pain
- Gymnast with low back pain
- Swimmer with low back pain
- L5-S1 isthmic spondylolisthesis– L5 nerve root
- TLSO with thigh extension

Basic Science

High Yield Facts



- Spinal fusions
 - NSAIDs decrease fusion rate
 - Ketoralac
 - Ibuprofen
 - Nicotine
 - Decreases
 - Smoking
 - Stop preoperatively and 6 months po^{stoperatively}

- When compared with cobalt-chromium and stainless steel implants, a titanium implant has what biomechanical properties?



- 1- Lower modulus of elasticity
- 2- Improved notch sensitivity
- 3- Increased hardness
- 4- Increased risk of corrosion
- 5- Decreased biocompatibility

Preferred response: 1

High-Yield: Axial Back Pain

Intradiscal Pressure



Highest

Sitting leaning forward

Sitting

Standing

Supine

Lowest

Test

High-Yield Facts



- Characteristics during disc degeneration?
 - Begins gradually during third decade of life
 - Glycosaminoglycan (GAG) levels in nucleus decline.
 - Water content decreases in the sixth decade and beyond.
 - Corresponding increase in noncollagen glycoprotein.



GAG & H₂O



Noncollagen glycoprotein

Traumatic Spine

Traumatic Spinal Conditions

Spinal Cord Neuromonitoring



- Stagnara wake-up
 - Gold standard
 - Especially for motor fxn
- MEP
 - Motor evoke potentials
 - Anterior column
- SSEP
 - Sensory=dorsal column=may miss anterior/motor fxn

Traumatic Spinal Conditions

Nerve Root Neuromonitoring



- Stagnara Wake-up
 - Gold standard
 - Good for both spinal cord and nerve root
- EMG
 - Identifies nerve root irritation
- Dermatomal
 - Nerve root
- Pudendal nerve root monitoring
 - Monitors S2-S4 nerve roots
 - Sacral tumors
 - ? Maybe high grade spondy

Important Facts



- Trauma
 - Radiographs must include C7/T1 junction
 - Adhere to ABCs and primary survey
 - Spine precautions
 - If there are associated facial fractures
 - Consider cricothyroidotomy for airway

High-Yield Facts



- Dens fracture Type II
 - Risk of Nonunion
 - 50 y.o.
 - 5 mm posterior displacement
 - 10 degrees angulation
 - Frontal oblique
 - Treatment chronic nonunion
 - Defined as 3 months or greater
 - PSF C1-C2
- Dens fracture Type III
 - Halo

High-Yield Facts



- Neurogenic shock
 - Lower cervical upper thoracic spine injury
 - Usually does not occur in SCI below T6
 - Loss of sympathetics
 - Bradycardic with hypotension
 - Peripheral vascular dilatation, hypothermia
- Spinal shock
 - Complete loss of all neurologic function below the injury level
 - Including reflexes and rectal tone

Traumatic Spine



- Spinal cord injury
 - Spinal shock
 - Unable to determine if complete or incomplete spinal cord injury
 - Complete
 - Return of bulbocavernosus
 - Lowest spinal reflex arch
 - Incomplete
 - Sacral sparing

Traumatic Spinal Conditions

Word Association



- Mechanism Jumped facet
- Distractive flexion
- Mechanism Chance
- Flexion distraction
- Mechanism Burst
- Axial compression

Traumatic Spinal Conditions

Fall from height



- Thoracolumbar burst fracture
 - Mechanism: axial load
- Surgical indications:
 - Neurologic deficit
 - Kyphosis > 30 degrees
 - Anterior loss of height > 50%
 - Retropulsion > 50%
- Most burst fractures can be treated nonoperatively

Traumatic Spinal Conditions

Fall from height



- Surgical Decision Making
 - Anterior decompression, fusion, and instrumentation
 - Neurologic deficit with retropulsion
 - Late treatment for deformity / post-traumatic kyphosis
 - Posterior procedure
 - LAMINA fracture → possible trapped nerve roots
 - Early treatment: 24-48 hours
 - Reduction through ligamento/annulotaxis with instrumented PSF
 - Laminectomy alone is not the answer!

Traumatic Spinal Conditions

Low" Lumbar Burst Fx (~L4, L5)



- Conservative treatment in most cases
 - Roots at this level
 - No conus to worry about
- Surgical indications are similar except for:
 - Kyphosis >20 degrees
 - Can't accept as much as at T/L jxn (30 degrees)
 - Majority of lumbar lordosis is at L4 to sacrum

Traumatic Spinal Conditions

MVA and lap belt



- Flexion distraction injury.
 - Usual at thoracolumbar junction
 - Don't miss associated visceral injuries!!!
 - Ileus. Perforation of duodenum or cecum.
 - Positive DPL.
 - Neurologic intact
 - Hyperextension bracing
 - Look for evidence of posterior element injury
 - MRI ligaments disrupted
 - Anterior loss of height > 50%
 - Splaying of posterior elements

Generalization about SCI



- Psychogenic erection not possible
- Normal ejaculation is not possible
- Reflex erections are possible with external stimulation
- Ejaculation possible with electro or vibratory ejaculation
- Sterility is a concern secondary to loss of thermal regulation of testes

Traumatic Spinal Conditions

Word Association



- HA, diaphoresis in SCI patient
- Autonomic dysreflexia
- What is autonomic dysreflexia?
- Sympathetic overdrive
- What should you look for in patients with autonomic dysreflexia?
- Orthopaedic issues, GU, GI

Factosarcomas



Anteriorly placed SI screws
place L5 nerve root at risk

Infections and Tumor

Pathologic/Infectious Spinal Disorders

Spinal Infections

- Osteomyelitis/Discitis
 - Biopsy for tissue diagnosis
 - Typically medical treatment
- Epidural abscess
 - Typically surgical treatment
- Granulomatous infection
 - Typically medical treatment
 - But look for late deformity

Factosarcomas

Tumor locations

- Posterior elements 😊😊
 - Osteoid osteoma
 - Osteoblastoma
 - Aneurysmal bone cyst
- Anterior body
 - Metastases
 - Giant cell tumor
 - Hemangiomas
 - Eosinophilic granuloma
 - Chondrosarcoma
 - Osteosarcoma

Chordoma



- Midline
- Primitive notocord-midline structure
 - Sacral-coccygeal 50% (sacral mass)
 - Occipitocervical 30%
 - Remaining spine 20%
- Surgical
- Not sensitive to chemoTx or XRT
- Cure: en bloc resection
- Histology: Physaliphorous cell



Classic CT: Osteoid osteoma

- Osteoblastic lesion
 - Osteoid osteoma < 2cm
 - Osteoblastoma > 2 cm
- 2nd and 3rd decade of life
- Pain
 - Unrelated to activity
 - Persistent
 - Noted mostly at night
- Response to aspirin is not universal



Classic X-ray: Winking Owl Sign

Think:

- Spine Tumor
- Pedicle missing
- Require 50% bony destruction to see lytic lesion on spine radiographic
- Obtain MRI with Gadolinium



Case Example:

Isolated Spinal Metastases



- Young female. Breast carcinoma. Isolated spinal metastases to vertebral body. Pain with neurologic deficits. Mgt?
- Considerations:
 - Young person
 - > 3-months life expectancy
 - Pain with neurologic compromise
- Answer: Surgery
 - Anterior
 - Corpectomy / Reconstruction
 - Instrumented fusion
 - PSF only as a supplement to anterior procedure

High-Yield Fact



- Best predictors of postoperative neurologic prognosis:
 - Pretreatment neurologic status.
 - 60 - 90% who are ambulatory at the time of diagnosis will retain this ability after treatment
- Location
 - Less space is available for the cord in the thoracic spine.
 - Lesions located in vascular watershed regions may disrupt the vascular supply of the cord.

Compression Fracture Risk



- 2 or more previous osteoporotic compression fractures
 - Future risk is increased by 12 fold
- A decrease of two standard deviations in BMD
 - Future risk is increased 4-6 fold
- Positive family history
 - Future risk increased by 2.7 fold
- Premature menopause
 - Future risk increased by 1.6 fold
- Smoking
 - Future risk increased by 1.2 fold.

Inflammatory Arthritis

Classic Imaging: Ankylosing Spondylitis



High-Yield Facts

Ankylosing Spondylitis



- **Features**
 - Limitation of chest expansion to 1 inch or less
 - Bamboo spine
- **Neck pain**
 - Assume fracture
 - Spine precautions
 - Admit
 - CT scan with recon
 - Halo immobilization (+/- Surgery)

Rheumatoid Neck



- Once neurologic symptoms → surgical intervention recommended
- AAS - atlantoaxial subluxation
 - Most common deformity
 - PADI more important
 - 10 mm and 14 mm
 - Fuse C1-C2
- AAI - atlantoaxial invagination
 - 4.5 mm above McGregor's line
 - Cervicomedullary angle (CMA) <135 degrees
 - Surgical intervention: Fuse to occiput
- SAS - subaxial subluxation
 - Fuse to the lowest level of sublux

28 y.o. LBP. Urethral discharge



- THINK: Reiter's Syndrome
- LBP
- Small joint polyarthralgia
- Nongonococcal urthritis
 - Urethral discharge!
- HLA-B27 in 88% cases
- Elevated ESR 72%

GOOD

LUCK !

Thank

You !